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EXPLOSIVE TECHNIQUES FOR HIGH ALTITUDE  
METAL RELEASES

Robert A. Fluegge

Calspan Corporation

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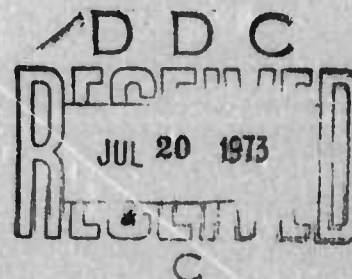
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Monitored by J. J. Simons, Project  
Engineer, Telephone (315) 330-3055  
RADC, OCSE GAFB, N. Y. 13440

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13. ABSTRACT

An experimental and analytical program to determine the effects of shock waves in porous iron is being undertaken. The overall goal is to cause sufficient vaporization such that dense clouds of Fe atoms can be generated. A large, high altitude test chamber and associated equipment have been instrumented for these tests. Initial results look promising.

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Robert A. Fluegge

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Phone: 315 330-3055

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This technical report has been reviewed and is approved.

  
RADC Project Engineer

## I. INTRODUCTION

A program is in progress to investigate experimentally the most promising techniques for the production of dense iron atom clouds. The overall goal is to obtain a better understanding of the processes that control the conversion of chemical energy into thermodynamic heating, and thus to produce more efficient techniques for obtaining dense clouds of free metal atoms. Shock heating techniques that cause vaporization in porous iron foils were evaluated. An oral review of this project was presented to ARPA on 30 April 1973; the following presents a summary of that review.



## II. EXPERIMENTAL APPROACH

Figure 1 shows the high altitude test chamber in which these experiments are conducted. It is 13 ft. in diameter and 40 ft. long, and is evacuated to pressures near  $2 \times 10^{-5}$  torr using the 36-inch oil diffusion pump shown at the right. The flyer launching assembly and iron target plates are located at the left, and the various diagnostic instrumentation is deployed downstream. A 1/2 meter Jarrell Ash spectrograph coupled to three photomultiplier tubes is used to measure the free iron atom densities. A high pressure, 1000 watt Xe arc lamp is used as a broadband light source. The integrated absorption over the pressure broadened atomic Fe lines is related to the line-of-sight densities between the arc lamp and spectrograph. The  $3720 \text{ \AA}$  absorption line in iron was used. For atom densities in the  $10^{14}$  to  $10^{16}/\text{cm}^3$  range, the absorption line width is proportional to the atom concentrations and ranges between a few tenths to several angstroms for practical optical pathlengths. We have set up a computer integration routine to estimate the line absorption for fixed spectrometer slit widths. The routine requires a numerical integration of the effective absorption coefficient as a function of atomic centerline densities, wavelength and spatial distributions. Figure 2 shows a typical computer output for the line absorption as compared to the measured spectrometer resolution.

Two additional optical slits and associated photomultipliers are attached in the exit plane of the 1/2 meter Jarrell Ash spectrograph to monitor the continuum absorption over  $20 \text{ \AA}$  bandwidths centered at  $3710 \text{ \AA}$  and  $3730 \text{ \AA}$ . The absorption at these wavelengths is used to estimate photon absorption due to particulate matter within the two-phase flow field. The correlation between these two signals is important, since when the Fe resonant absorption signal drops below that corresponding to the particulate matter, this signals the first arrival of free iron atoms within the light path. These signals are then processed and used to determine the iron vaporization efficiencies.

Two explosive configurations have been tested; they are shown pictorially in Figures 3 and 4. A configuration designed by Dr. Michel at the Max-Planck-Institut (M.P.I.) and purchased for this program from the Messerschmitt-Bolkow-Blohm Company for comparative purposes is shown in Figure 3.



The assembly has successfully been used to launch 0.005" and 0.010" thick, 1" dia. Tantalum flyer plates at velocities up to 5 km/sec. A similar configuration designed at the Calspan Corporation is shown in Figure 4. This design when coupled with the PBX-9404 high explosive main charge has produced flyer plate velocities 5 to 10% greater than the M.P.I. design. Its main advantage, however, is due to its ability to be scaled for launching flyer plates having diameters larger than the 1.2 inches used here. Each of the small circles in the distributor plate is effectively an ignition point, and no special lensing designs are required for larger payloads.

### III. EXPERIMENTAL RESULTS

A series of experiments were performed to investigate the probability for vaporization in porous iron which has been shock heated and allowed to isentropically expand into a vacuum. Iron having densities of 83%, 73% and 58% of normal was subject to various flyer plates having different thicknesses and velocities. Only when the main charge and flyer launch system was enclosed in a 1 inch thick steel housing was vaporization measured. The results from one of these experiments is shown in Figure 5. The solid curve shows total absorption due to particulate matter. The dashed curve presents the sum of absorption due to particulate matter and resonance absorption in ground state iron at 3720 Å. The difference between these two curves can be related to the free iron atom densities. This relationship will be included in the next semiannual report on this program.

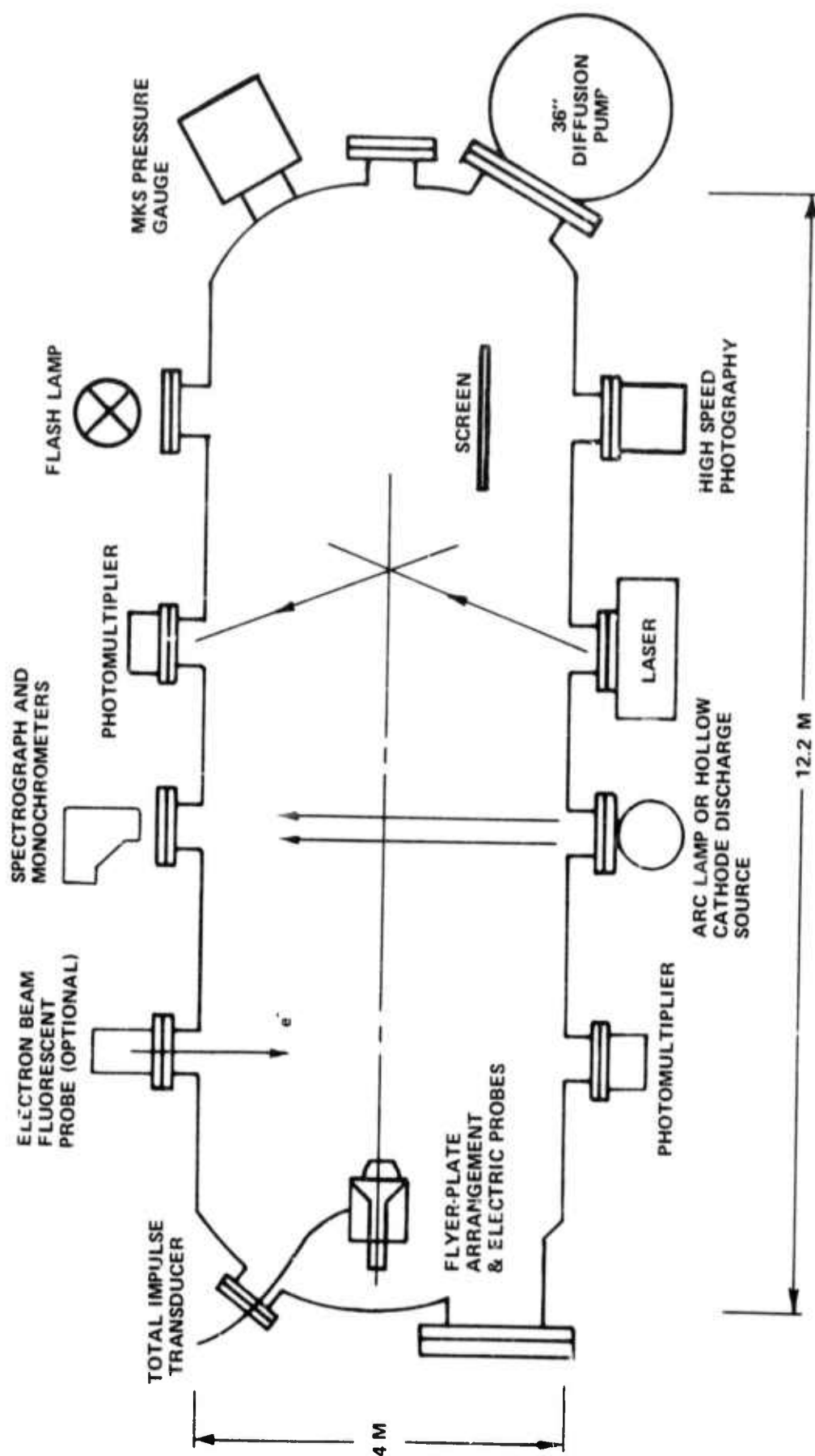


Figure 1 CALSPAN HIGH ALTITUDE METAL RELEASE TEST FACILITY

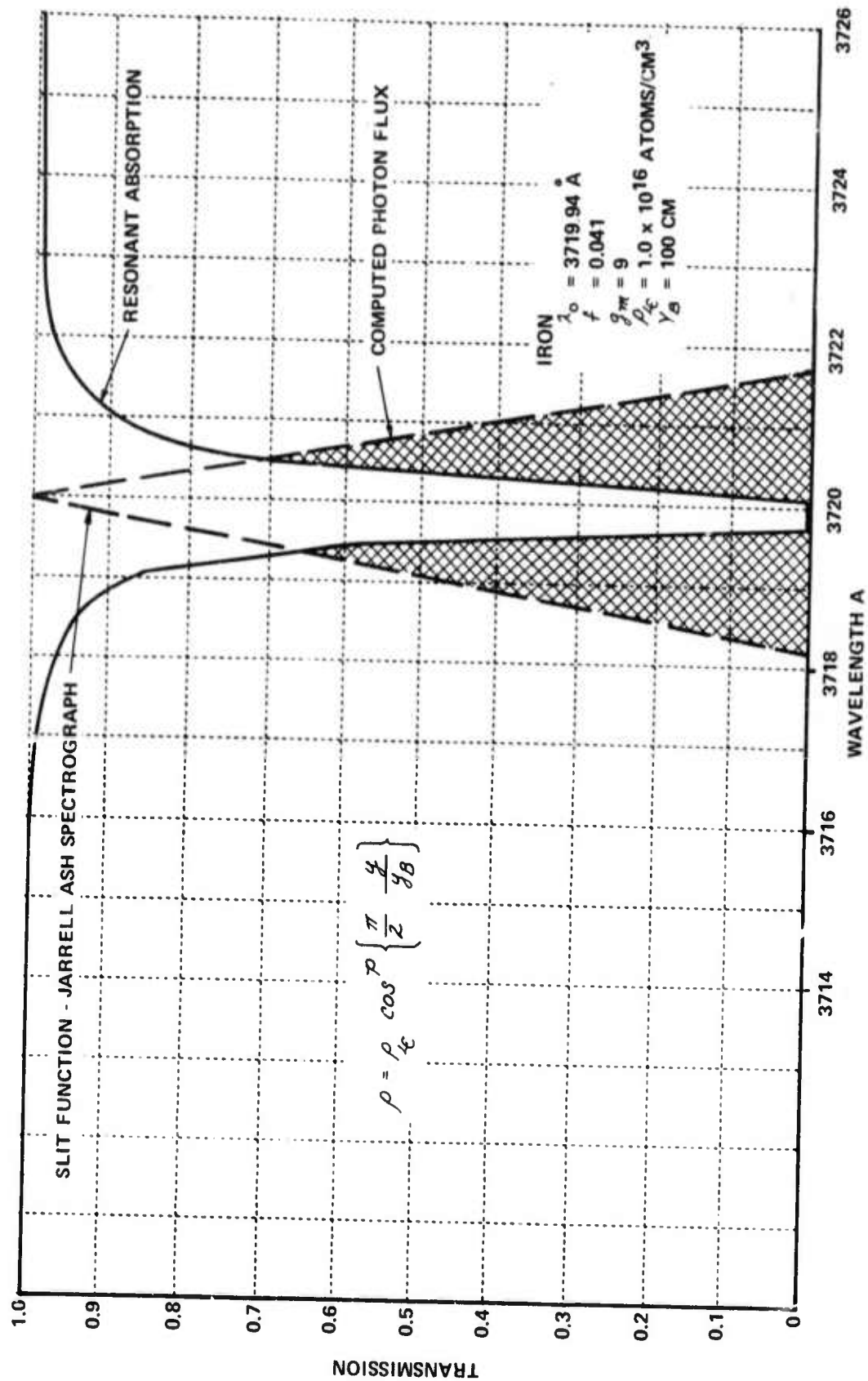


Figure 2 PRESSURE BROADENED ABSORPTION

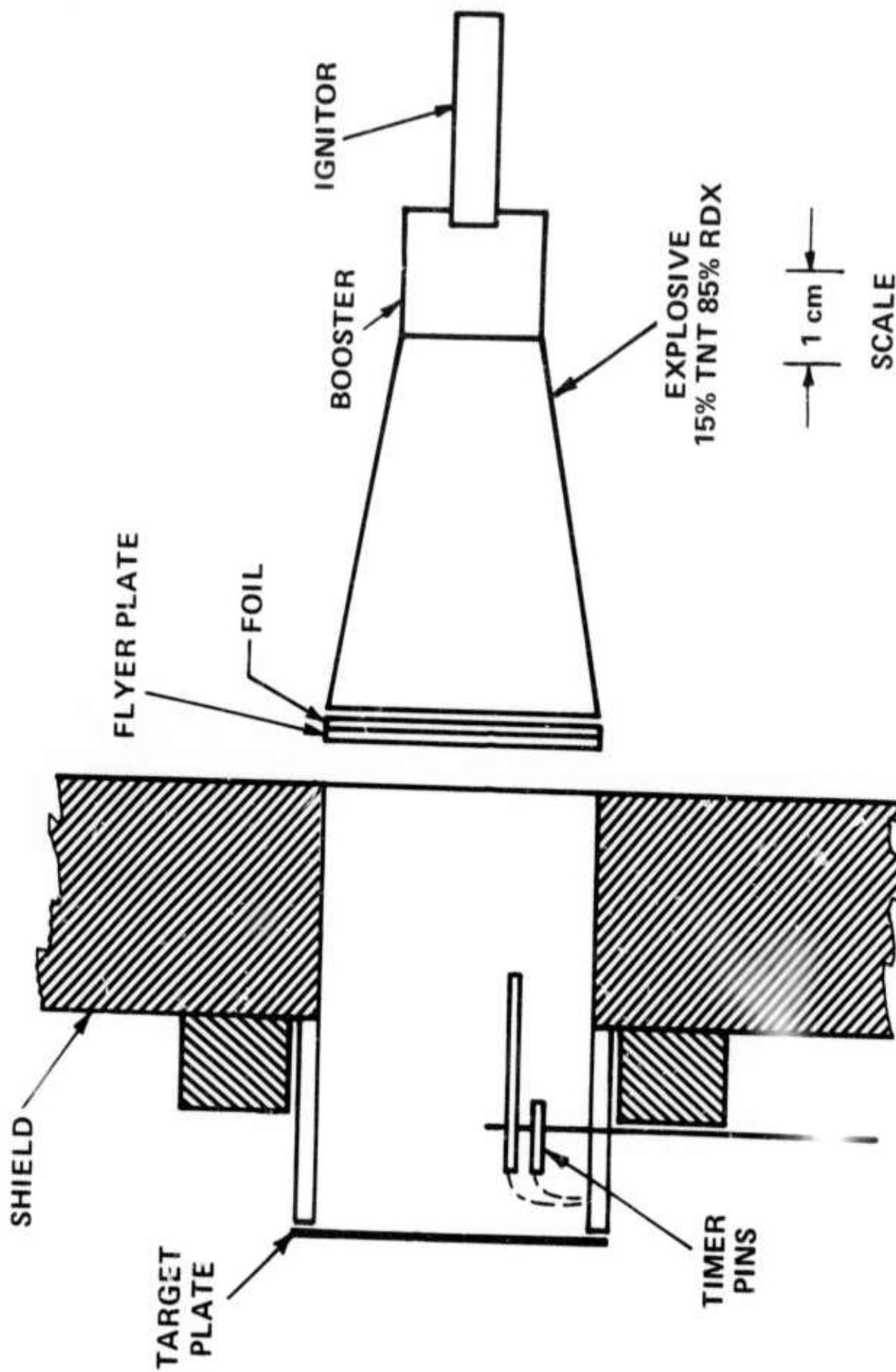


Figure 3 M.P.I. TYPE FLYER PLATE LAUNCH ASSEMBLY

1. REYNOLDS RP-2 EBW DETONATOR
2. FOIL, 2 MIL AL
3. DETONATOR HOLDER
4. DISTRIBUTOR PLATE, EXTRUSION LOADED  
W/EXTREX 8003 HIGH EXPLOSIVE
5. H.E. BOOSTER PELLET, PBX-9407
6. F.E. MAIN CHARGE W/ALTERNATE EXPLOSIVES  
PBX-9404  
PBXN-5  
HNS-II
7. POLYACETATE FILM
8. FLYER PLATE, 1.17" DIAMETER

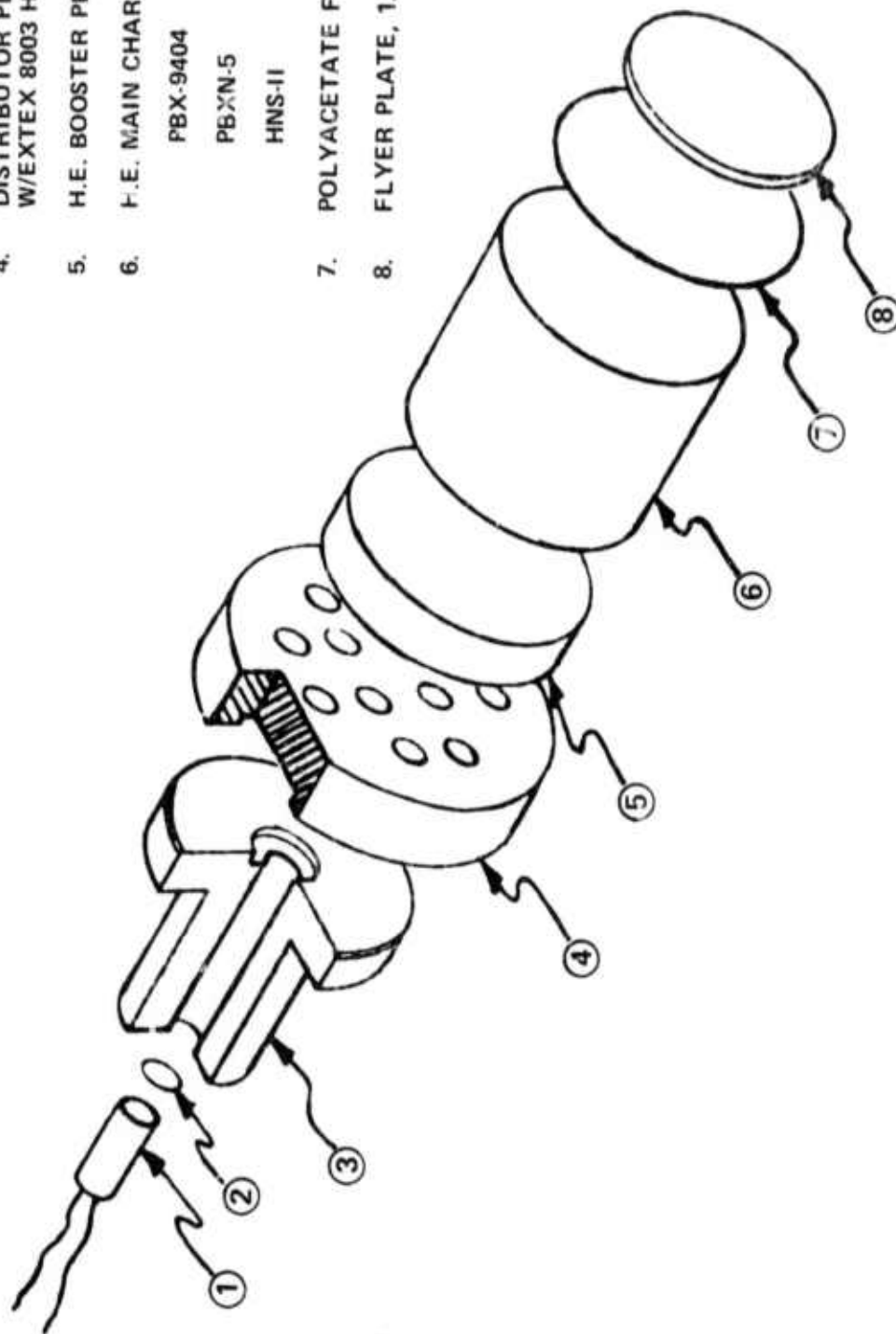


Figure 4 CALSPAN FLYER PLATE LAUNCH ASSEMBLY

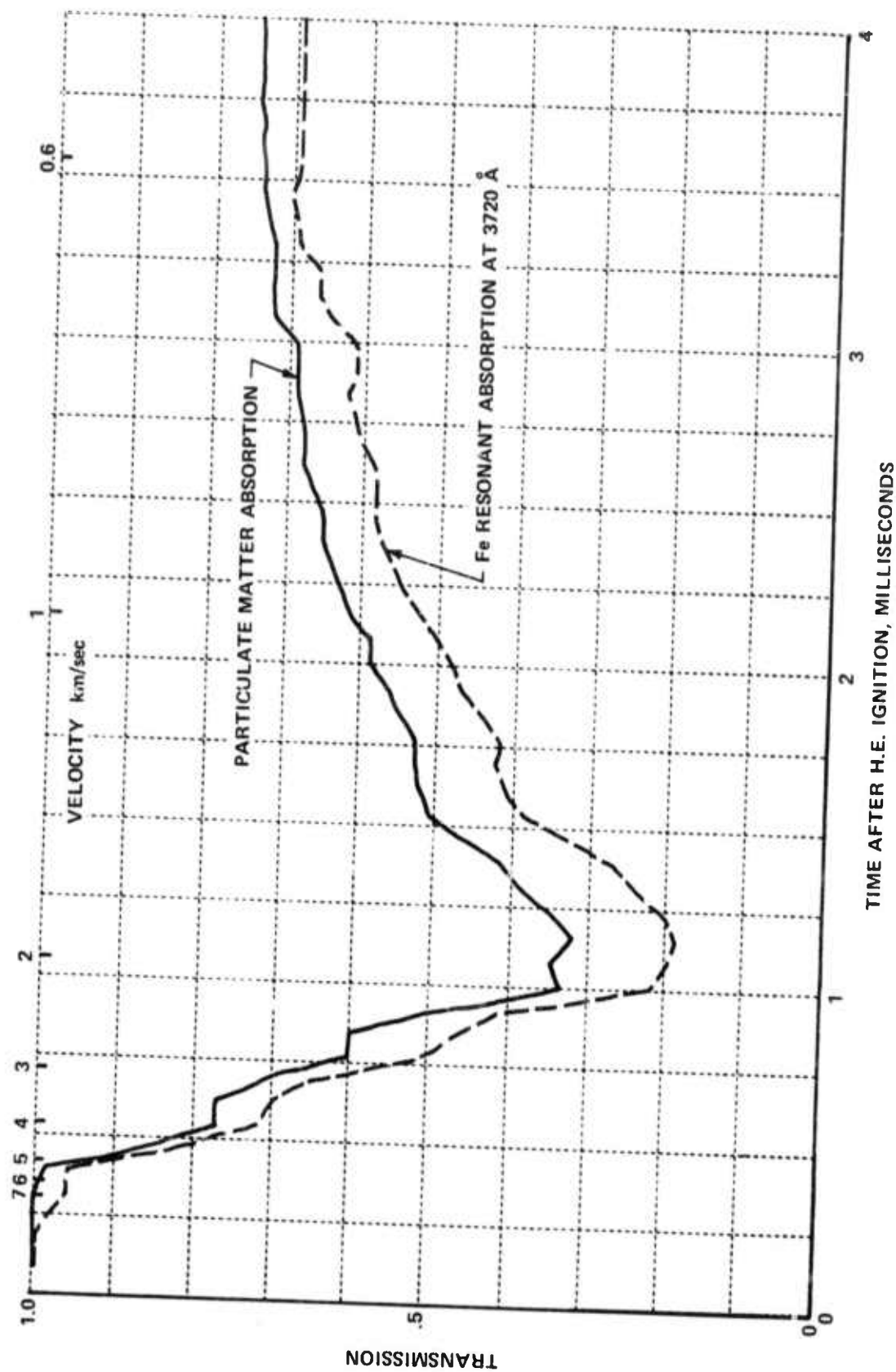


Figure 5 MONOCHROMETER SIGNALS SHOWING Fe VAPORIZATION